

Magellan: Principal Venus Science Findings

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This is a brief summary of the science findings of the Magellan mission, principally based on data from the radar system. Future plans for Magellan include acquisition of high resolution gravity data from a nearly circular orbit and atmospheric drag and occultation experiments. The Magellan science results represent the combined effort of more than 100 Magellan investigators and their students and colleagues. More extensive discussions can be found in the August and October, 1992 issues of the Journal of Geophysical Research, Planets [1]. The Magellan mission's scientific objectives were (1) to provide a global characterization of landforms and tectonic features; (2) to distinguish and understand impact processes; (3) to define and explain erosion, deposition, and chemical processes; (4) to model the interior density distribution. All but the last objective, which requires new global gravity data, have been accomplished, or we have acquired the data that are required to accomplish them.

Synthetic aperture radar imaging and altimetry were acquired over nearly 99% of the planet with resolution between 120 m and 300 m and at least four looks. Several image geometries were obtained in order to provide the best interpretation of the landforms. For the first 243 day cycle, one Venus rotation, an incidence-angle, or look-angle, profile was used that maximized the image resolution and overall quality everywhere along the orbit. This profile caused the incidence angle to vary from about 15° over the north pole to 45° at the equator. In the first cycle we mapped 83% of Venus, more than meeting the primary mission objectives. In the second mapping cycle, mapping was restricted in order to control spacecraft temperature. Image data were obtained at a constant incidence angle, and looking to the right (toward the west) in the opposite direction from cycle 1. Also, in cycle 2, some of the major gaps were filled with the same incidence angle profile as used in cycle 1. In cycle 2, we also conducted a successful test of a stereo mode in which we imaged at a slightly different angle than in cycle 1. The stereo was so useful that it was decided to devote much of the third mapping cycle to acquiring stereo images. All of the radar image data were processed at JPL in a complex flow that begins at the DSN stations at Goldstone, Madrid, and Canberra. In addition to images and altimetry, Magellan also acquired radiometer data whenever images were obtained [2]. The radiometry samples the radio emission of the surface at the radar wavelength. Emissivity varies from place to place because of variations in surface properties.

Imaging was terminated at the end of the third cycle and gravity data are being acquired during cycle 4. This is accomplished by pointing the 3.8 m high-gain antenna toward Earth during the periapsis part of the orbit and recording the returned radio signal

at the DSN. From this signal we extract the slight accelerations of the spacecraft as it orbits Venus and convert these accelerations into gravity maps that tell us about density variations in the interior.

Magellan image data have provided several improvements in knowledge of the fundamental planetary constants for Venus. The rotation period of Venus was refined to 243.0185 ± 0.0001 days and the north pole direction, in J2000 coordinates, has been refined to right ascension $272.76^\circ \pm 0.02^\circ$ and declination $67.16^\circ \pm 0.01^\circ$. The mean radius was refined to 6051.84 km, with the lowest point 6048.0 km and the highest point 6062.57 km [3].

Magellan has established volcanism as the dominant surface process on Venus [4]. Volcanism is broadly distributed, not completely random, but does not form linear patterns as on Earth where major volcanic activity tends to occur along plate boundaries. Image analysis reveals thus far 556 shield fields, 274 volcanoes 20-100 km, 156 volcanoes 100 km, 86 calderas (not on shields), 259 arachnoids, 53 lava flow fields, 200 sinuous lava channels, 145 steep-sided domes (pancakes) [4]. Over 360 coronae and corona-like features have been identified [5].

Tectonics is a major process [6], with evidence for extension and compression. Steep slopes (20° - 30°), up to tens of km in extent, provide evidence of active tectonics. Deformation is more distributed than on Earth. Shear zones are seen in complex ridged terrain. Trench topography resembles terrestrial subduction. An extensive equatorial zone of fractures is among the most recent tectonic features.

More than 900 impact craters 1.5 km to 280 km have been identified [7,8]. There appears to be a globally random distribution yielding an average surface age of about 500 Myr. Both bright and dark splotches appear to be shock signatures. Most craters are unmodified. Bright and dark E-W oriented parabolic halos are associated with about 20% of craters [9].

Surface processes and surface properties [10,11,12] investigations yield more than 8000 mapped wind streaks with directions consistent with Hadley circulation. Possible dune fields have been identified and there is widespread evidence of landslides [13]. Anomalous left-right reflectivity behavior indicates unusual surface reflectivity behavior, possibly caused by asymmetric shapes. Anomalous low emissivity in elevated regions has been confirmed [2].

Major questions about Venus remain unresolved, pending acquisition of new data and further analysis of existing data. Interpretation of the impact crater population suggests a major secular change in the rate or style of resurfacing [7], but the details or even the reality of this change, whether catastrophic, cyclical, local or global scale is unknown. High-resolution global gravity data will help address some of the unresolved issues concerning the

generation, support, and relaxation of topography.

References: [1] R.S. Saunders et al., J. Geophys. Res., 97, E8, 13,067, 1992; [2] G.H. Pettengill et al., J. Geophys. Res., 97, E8, 13,091, 1992; [3] M.E. Davies et al., J. Geophys. Res., 97, E8, 13,141, 1992; [4] J. W. Head et al., J. Geophys. Res., 97, E8, 13,153, 1992; [5] E.R. Stofan et al., J. Geophys. Res., 97, E8, 13,347, 1992; [6] S. C. Solomon et al., J. Geophys. Res., 97, E8, 13,199, 1992; [7] G.G. Schaber et al., J. Geophys. Res., 97, E8, 13,257, 1992; [8] R.J. Phillips et al., J. Geophys. Res., 97, E10, 15,923, 1992; [9] D.B. Campbell et al., J. Geophys. Res. [10] G.L. Tyler et al., J. Geophys. Res., 97, E8, 13,115, 1992; [11] R.E. Arvidson et al., J. Geophys. Res., 97, E8, 13,303, 1992; [12] R. Greeley et al., J. Geophys. Res., 97, E8, 13,319, 1992; [13] M.C. Malin, J. Geophys. Res., 97, E10, 16,337, 1992.

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